WATER AND ITS CONSERVATION

A Youth Publication

by M. F. MILLER

UNIVERSITY OF MISSOURI *COLLEGE OF AGRICULTURE*

Agricultural Experiment Station

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WHAT YOU WILL FIND IN THIS BULLETIN

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M. F. MILLER*

Our forefathers got their water mainly from a spring, from a cistern or from the old oaken bucket that hung in the well. After a hot day in the fields, the farm boys often lay on their stomachs to drink from the spring. Sometimes they used a gourd in drinking from the oaken bucket at the well or cistern. Those were the days when water was considered wholesome whether it came from a spring, a cistern, or from a dug well. That from a good cistern was judged to be excellent by those who had developed a taste for it.

In the early days the boys and girls helped their mothers carry many buckets of water from the spring at the foot of the hill, or from a well which was often a good distance from the house. For some reason the fathers didn't seem to do much of this work. But times have changed! On many good farms today, the fathers have sunk deep wells from which the water is raised by pumps, usually powered by electicity, and brought in the same way to the houses. On such farms it is now merely a matter of turning a faucet, rather than lugging buckets of water. This is certainly a great advance from earlier times.

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The Importance of Water

Water is one of the most important of earth's natural resources. About 90 per cent of green growing plants and approximately 75 per cent of the human body is water. It is necessary for the growth of every living thing from bacteria to man. The course of civilization throughout history has been determined by availability or lack of water. Entire civilizations have perished because of the failure of irrigation water in the region where they had developed.

The earth's water is the same, yesterday, today, and forever. It may change its form from an invisible vapor in the air, to clouds, rain, snow, ice, or to flowing or stored water, in streams, lakes, and the sea; yet it is always of the same composition, wherever it is found. It is made up of two parts of the element hydrogen and one part of the element oxygen, as expressed in the chemist's symbol H_2O.

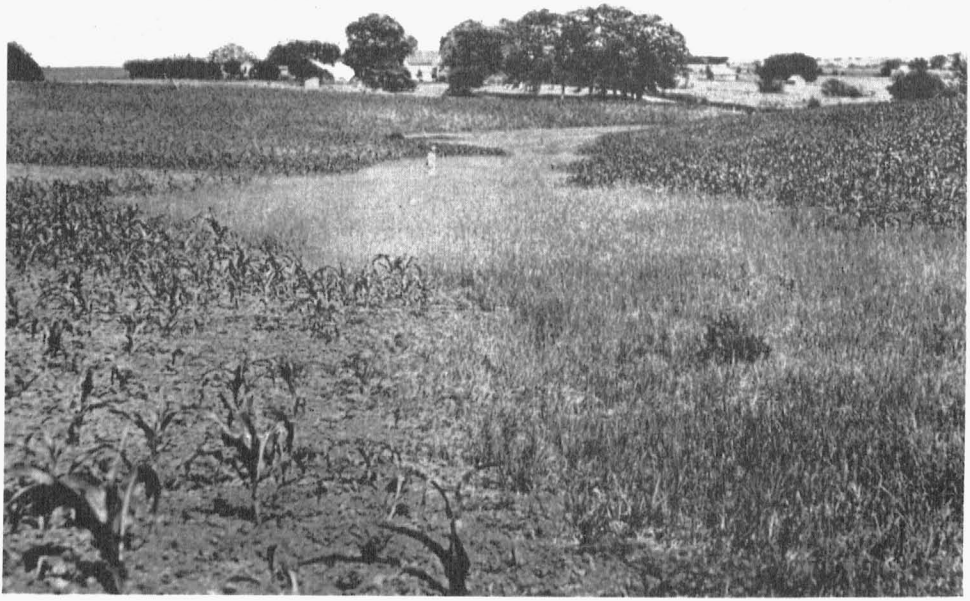
Water has been necessary for the breaking down of rocks in the formation of soils. It has been largely responsible for the form of the earth's surface as it exists today. On its ocean

surfaces, ships transport tremendous quantities of materials throughout the world, and this means much to industry, commerce, and agriculture. You have heard of the boy whose teacher asked him to give a use for water. He replied, "Well, it helps us to reach the islands." He was thinking straight regarding water for transportation, but he had a unique way of telling about it.

Man is dependent on water in one way or another for practically everything he does. It is sometimes said that soil is our most important natural resource, because it supplies us with most of our food. It must be remembered, however, that man can live for weeks without food, when necessary, but for only a few days without water.

Water and Natural Plant Life

When Daniel Boone first came to the region we now know as Missouri, he found the forests and prairies just as nature had developed them. The Indians had changed them very little. The locations of these two types of natural vegetation, trees and grasses,



This farm is in a region of abundant rainfall. Through the action of heavy rains much soil erosion has taken place. The farmer now keeps the main drainage ways in grass to prevent the formation of gullies.

had been partly determined by soil conditions, but water had been the most important factor.

Forests are found in regions of abundant rainfall; prairies occur where the rainfall is less abundant or the evaporation is high. Some timber is usually found along streams in the prairie regions because the trees are more protected from wind and evaporation and they can usually get more water there.

Some wild plants are naturally adapted to swamp lands. Most young people who have been reared near such wet land areas, know the important trees in swamp timber and the types of wet land vegetation which grow there. Some plants grow only in standing water. There is a great variety of these, from cattails to cypress trees.

At the other extreme from the swamp plants are those growing in

Dry land vegetation like this is found in many parts of the dry West. The plants are scattered and small. The average yearly rainfall is less than ten inches.

the drier areas of the country. In such places, plants are found that can live and grow on very small amounts of water. Examples of these are the cactus plants, sage brush, the creosote bush, and the very short dry land grasses. Dry land plants have adapted themselves to dry conditions. While most of them make small growth or they grow very slowly, they nevertheless grow and multiply, even with the very small amounts of water available to them.

There is certainly a great difference between the dry land plants and the great Sequoia trees of certain well-watered areas of California, some of which are twenty-five feet or more in diameter and thousands of years old. And the principal reason for this tremendous difference between these two types of natural growth is the mois-

Timbered swamp land in Southeastern Missouri. This is a case of too much water. Large areas of the lowlands of this part of the state were formerly in swamp. They are now almost entirely drained and used for agricultural purposes.

ture in the air and the water in the soil, at the places where they are growing.

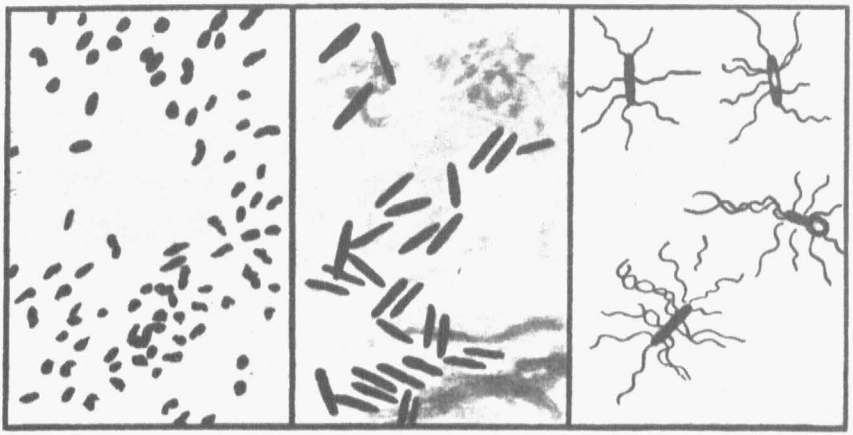
Microscopic Plants Need Water

In the soil are enormous numbers of microscopic plants which require water for growth. The most important of these are the *bacteria* and the *fungi* which feed on the organic matter in the soil, such as the dead roots, leaves and stems of plants. The numbers of these in a fertile soil, well supplied with organic matter and with moisture, are very great. A single gram (about a half teaspoonful) of soil from a fertile field usually contains from two to four millions of bacteria along with very large numbers of fungi. These organisms have very beneficial effects on the soil and are absolutely necessary for keeping the soil fertile. Without them the soil would be unproductive and man would disappear from the earth.

Agricultural Crops Require Large Quantities of Water

Investigations have shown that it takes many hundreds of pounds of water, going into crops through the roots, to build one pound of dry substance. To produce one bushel of Missouri ear corn, for instance, 18½ tons of water, or about 4,400 gallons are used by the corn plants. Likewise, a 50 bushel crop of oats in northwestern Missouri requires about 1,000 tons of water per acre.

These figures regarding water used by crops are almost unbelievable and most people want to know how a crop uses so much. It's rather easy to understand when one considers the fact that crops are constantly *transpiring,*



Drawings of three kinds of beneficial soil bacteria as seen through a high power microscope. They are enlarged several thousand times. Their growth is dependent on a supply of water as well as of air and food. (Waksman)

or breathing out water, through small pores in the surface of their leaves. While this loss through the leaves slows down at night, or when the weather is damp and rainy, it speeds up greatly during sunny days of summer.

Often the loss through the leaves of a crop, during hot summer days, is so great that the roots cannot take up water fast enough and the crop begins to wilt. Most farmers recognize this in the wilting of clovers and particularly in the rolling of corn leaves during periods of drought. Corn leaves may roll together to lessen the surface exposed to the dry, warm air during the hot afternoons and thus cut down the water lost by transpiration. It's interesting to observe, however, that during the night when the water loss goes down they unroll again. In the morning they look quite normal, only to roll once more in the afternoon if the hot, dry, summer weather continues. Crops, of course, use some water in building up their tissues, but this is small compared to the amount going off through the leaves.

Water and Wildlife

Most people take it for granted that the wildlife of our forests and fields, has an abundance of water in the streams, ponds, and lakes. While this was generally true before the land was put into cultivation there are many cases now where wild animals suffer for want of it. As a matter of fact, the digging of ponds for stock water and the building of reservoirs, in recent years, have greatly improved the conditions for the growth of wild animals and birds common to farm lands.

There are certain animals and birds which live around bodies of water and secure most of their food from these sources. Wild geese, wild ducks, and a great variety of the wading birds, large and small, spend much of their time in or on the water.

If this field of corn makes 60 bushels per acre when it is mature, it will have taken 1000 tons of water from each acre to do it. That's a lot of water!

Animals such as the beaver, muskrat, and otter are dependent upon water for their homes and much of their food. These water animals are some of the most interesting in Nature. While their numbers have been greatly reduced by trappers, some are now increasing in Missouri, due to the protection and assistance of those charged with wildlife conservation.

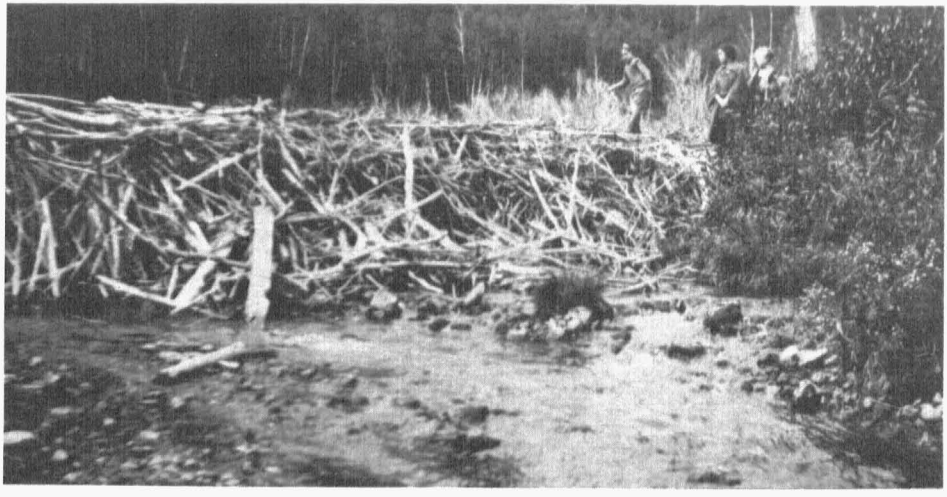
Fresh Water and Salt Water Fish

The most important representatives of wildlife which live entirely in water are the many kinds of fresh water and salt water fish. The enormous supplies of these in the sea were formerly thought to be inexhaustible, and in general, this is true. However, the large scale fisheries along some of our coasts, have reduced the num-

This field of corn is suffering terribly from drought. By looking at the picture closely you can see that the corn leaves, or blades, are "rolled up," possibly to cut down further loss of water.

bers of some of these fish to a much lower level than formerly. Actually, fish form a great portion of the food of the people of certain nations such as the Japanese, the Philippinos, and some other orientals. Likewise, the people of Western Europe, who live near the sea, notably the English, Norwegians, the Danes, and the Irish are great fish eaters.

The Missouri Conservation Commission is making progress in developing greater quantities of fresh water fish in Missouri. The artificial lakes, or reservoirs, that have been developed for town and city water supplies and for electric power, should increase the quantities of this important type of wildlife. Stock water ponds in Missouri are coming into greater use for



This dam across a stream was constructed by beavers in order to make a pool of water above it in which to build their homes. The beaver is an amazing type of water animal.

Missouri has more farm ponds than any other state. They supply water for livestock as well as for different forms of wildlife. Many are now stocked with bass and bluegills so that they provide good fishing.

the production of fish, thus providing both food and fun for farm people. The old-time neighborhood *fish fries* are being revived as pond fish becomes more abundant.

Water for Domestic Animals

Every farm boy knows the importance of water for farm animals. Often one of his important jobs is to see that the stock is well supplied. While this water comes largely from springs, streams, shallow dug wells and farm ponds, deep wells are becoming more and more common in supplying water for household use and for livestock. On farms where regular water systems are installed, plans are usually made for a ready supply for animals at all times. Missouri is noted for its many stock ponds. One of the interesting features of the Missouri landscape from the air is the great display of these ponds which one sees.

PEOPLE ARE DEPENDENT ON WATER IN VERY MANY WAYS

Next to the oxygen in the air, water is more important than any other thing for man's life processes. Moreover, he has multiplied greatly the uses he makes of it.

Drinking Water

Everyone knows the value of wholesome drinking water. Unfortunately, this is not always easy to get. As people have multiplied, diseases have spread, and some of them are now carried by drinking water. Where towns and cities secure their water supplies from stream or lakes, disease organisms are almost always present. It is a common practice, therefore, to treat the waters with chlorine to make them safe for drinking. Even when

deep wells are depended upon for city or town water supplies, there is some danger of disease organisms getting into the water after it has been brought to the surface. As a result such water is often treated, as is stream or lake water, in order to insure its safety for family use.

In earlier times typhoid fever was common, coming from shallow wells or streams. With proper control of the water supply this is now becoming rare. Scourges of it still develop occasionally, where people drink unpasteurized milk from a dairy which uses wash water from a shallow well containing the typhoid bacteria. Country people are often careless about the care of shallow wells, and typhoid may attack two or three members of the family. Most people, however, have learned how to take care of water supplies for drinking purposes so that danger from water-borne diseases is no longer so common.

Water for Washing and Sanitation

Farm people usually do their own washing. They rarely depend on town laundries. As a consequence, a supply of good water, not too hard, is necessary for laundry, bathroom, and kitchen. The so-called *detergents,* or washing powders, are making hard water more readily usable than formerly, and with electricity for pumping, the whole matter of the water supply is being simplified.

Water has become very important for sanitation in rural and city homes and large city sewer systems. The whole system of bathroom waste disposal is dependent on a sufficent water supply. Unfortunately, sewage water emptied into streams always carries downstream more or less foul material, or pollution. This along with the wastes of manufacturing plants may make the water entirely unfit for household uses. Trouble often comes when the stream is too small to ab-

A summer cottage on a beautiful lake. A vacation in such a spot is most enjoyable.

sorb the sewer water readily or during periods of summer or fall when the stream may run low. It is really essential to maintain a good flow of water past the larger cities if the sewage is properly removed. The whole matter of stream pollution is one of the great problems of our present-day civilization.

Recreational Uses of Water

Most people prefer that their special vacation time be in some way associated with water. The sea, the lakes, the rivers, as well as the large farm ponds, provide favorable places for recreation. Boating, swimming, and fishing are all very enjoyable and many vacation resorts have been developed because they make possible this type of recreation. In the northern states, ice boating and skating, in the winter season, are very enjoyable.

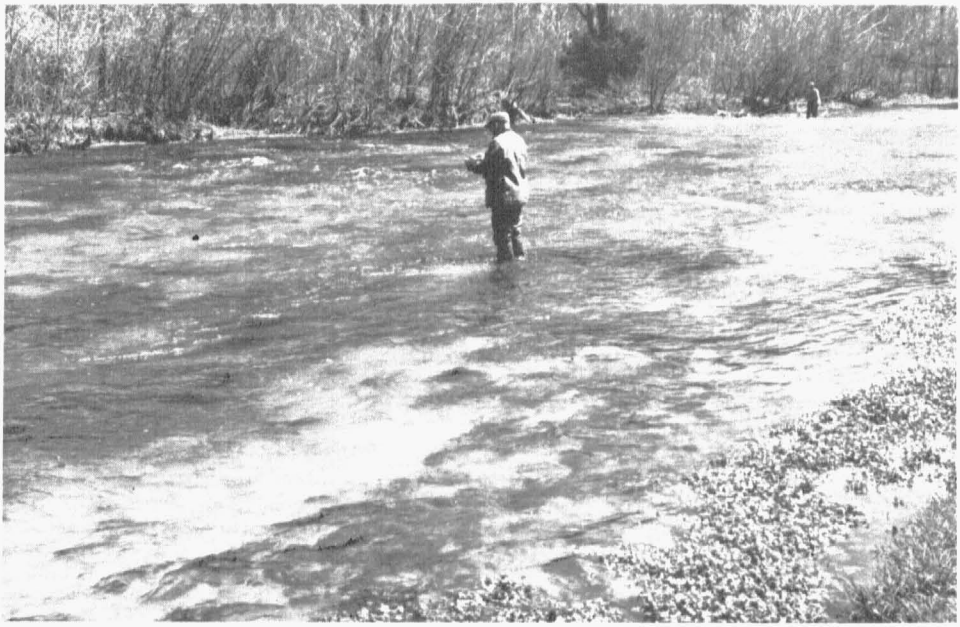
In Missouri, the Lake of the Ozarks, and the waters of Taneycomo, Wappapello, and Clearwater reservoirs are furnishing Missouri people, as well as many from other states, with high types of recreational facilities. The Lake of the Ozarks has about 1,200 miles of shoreline, equalling the distance from Kansas City to New York. This is because the 90 foot rise from the original level of the Osage River causes the impounded waters to extend far up into the valleys of many creeks and small streams. From the air the lake looks like an immense centipede with a great number of legs.

Among the interesting water recreation spots in Missouri are those surrounding the big springs. These springs come from streams flowing out of openings in the great beds of limestone rock in Southern Missouri.

There's a lot of fun in winter sports. Coasting is one of the most enjoyable and exciting. It's remarkable how "slick" water can become when frozen.

In many cases they are real rivers. Big Spring, the largest one, near Van Buren, has an average daily flow of 252,000,000 gallons; Greer Spring, the second largest, has an average daily flow of 214,000,000 gallons. There are many others with daily flows from 20,000,000 to around 100,000,000 gallons.

Most of the streams flowing from these springs are stocked with trout which provide good fishing. The water in most Ozark streams is clear and offers good fishing for many game fish such as bass, crappie, bluegills, Jack salmon, and some smaller kinds of fish.



These men are fishing for trout in the waters of Bennett Spring in the Missouri Ozarks. See what a tremendous amount of water flows from this one spring; yet there are several larger ones in the Ozark region. (Courtesy Soil Conservation Service)

CLOUDS, RAIN, AND SNOW

The bulk of the earth's water is in the oceans. However, some of it is constantly evaporating into the air where it exists as an invisible vapor. Warm air will take up more water than will cold air so that in the Northern Hemisphere the southern parts of the oceans supply more water to the air than do those farther north.

When air carrying moisture is cooled, much of the vapor is condensed into very fine droplets which form fogs or clouds. The fogs which often occur over the seas are really clouds in contact with the ocean surface. Almost everyone who has taken a long sea voyage is familiar with these fogs. The constant sounding of the ship's

These boys are learning to cast for bass on a small lake. Few water sports are more interesting to young folks than fishing.

fog horn, when a fog is encountered, is to avoid possible collision with other ships. This weird sound as the ship passes slowly through a dense fog, is something one never forgets.

Clouds Over the Land

Not all fogs, or clouds, occur over the oceans. Some of this moisture-laden air is carried from the oceans over the land by normal air movements. When this occurs the moist air frequently comes in contact with cooler air and clouds are formed. If the cooling goes far enough the very small water droplets, making up the cloud, come together to form larger ones.

Nothing is much more beautiful in Nature than a deep covering of clean new-fallen snow.

These, in turn, come together to form still larger ones which fall to the earth as rain.

If the air is greatly cooled, ice crystals will form. The clouds in the very cold air, far above the earth, usually consist of these ice crystals. In the winter, both the higher and the lower clouds may be made up of ice crystals which come together to form snow flakes, and give us the interesting snows of winter.

To one who has been reared in Missouri or any of the North Central States, the rains of summer and the snows of winter add much to the joy of living. Think how dull it would be to live in a region where the weather was the same every day in the year! Some scientists say that the highest types of civilization in the world will always be found in regions where there are wide variations in climate between summer and winter.

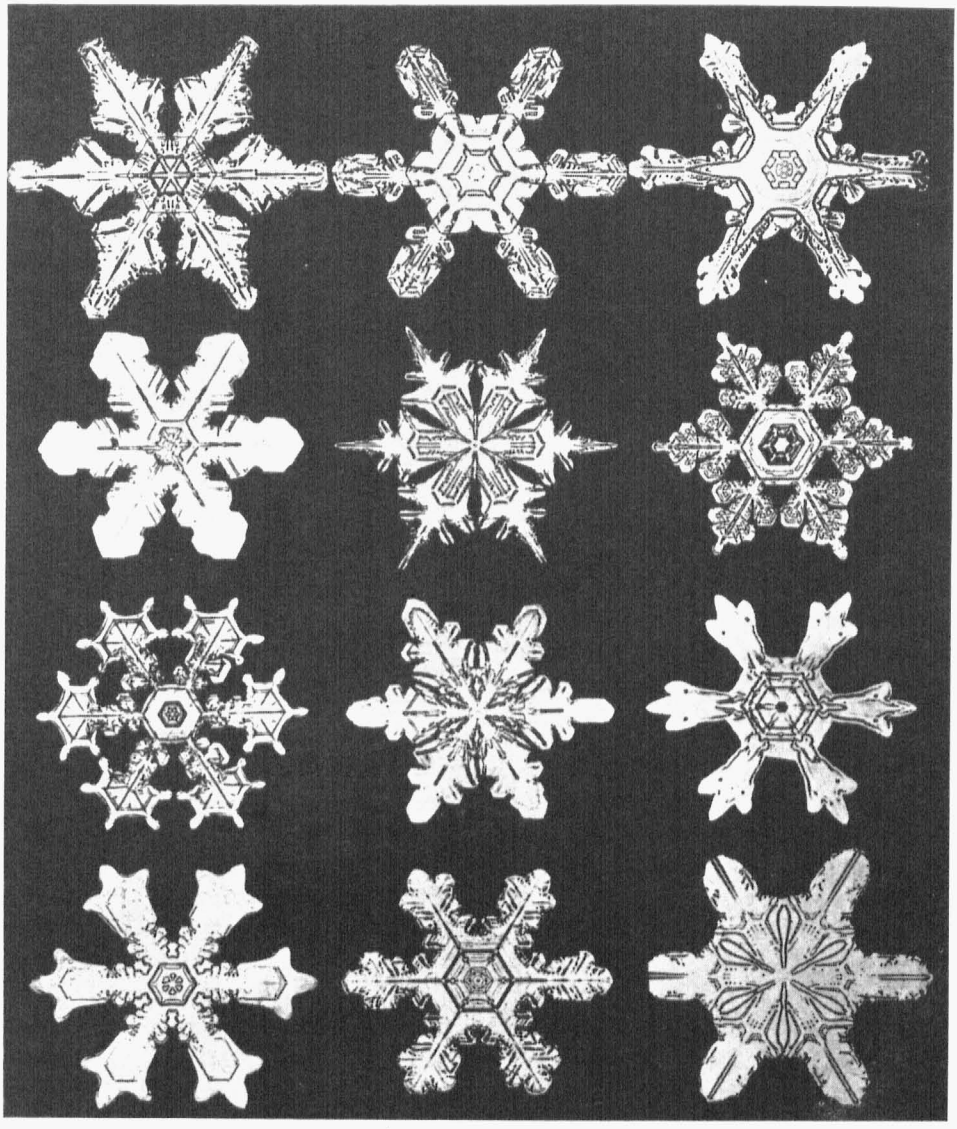
General Rains

Rains that last for a half day to a day or two, are the result of large-scale movements of warm, moist air over the country. Always, when this warm air is lifted some distance above the earth by a cooler mass of air below, clouds will form and rain will usually result. In this way, warm moist air from the Gulf of Mexico moves northward until it strikes a large mass of cooler air spreading southward from Canada.

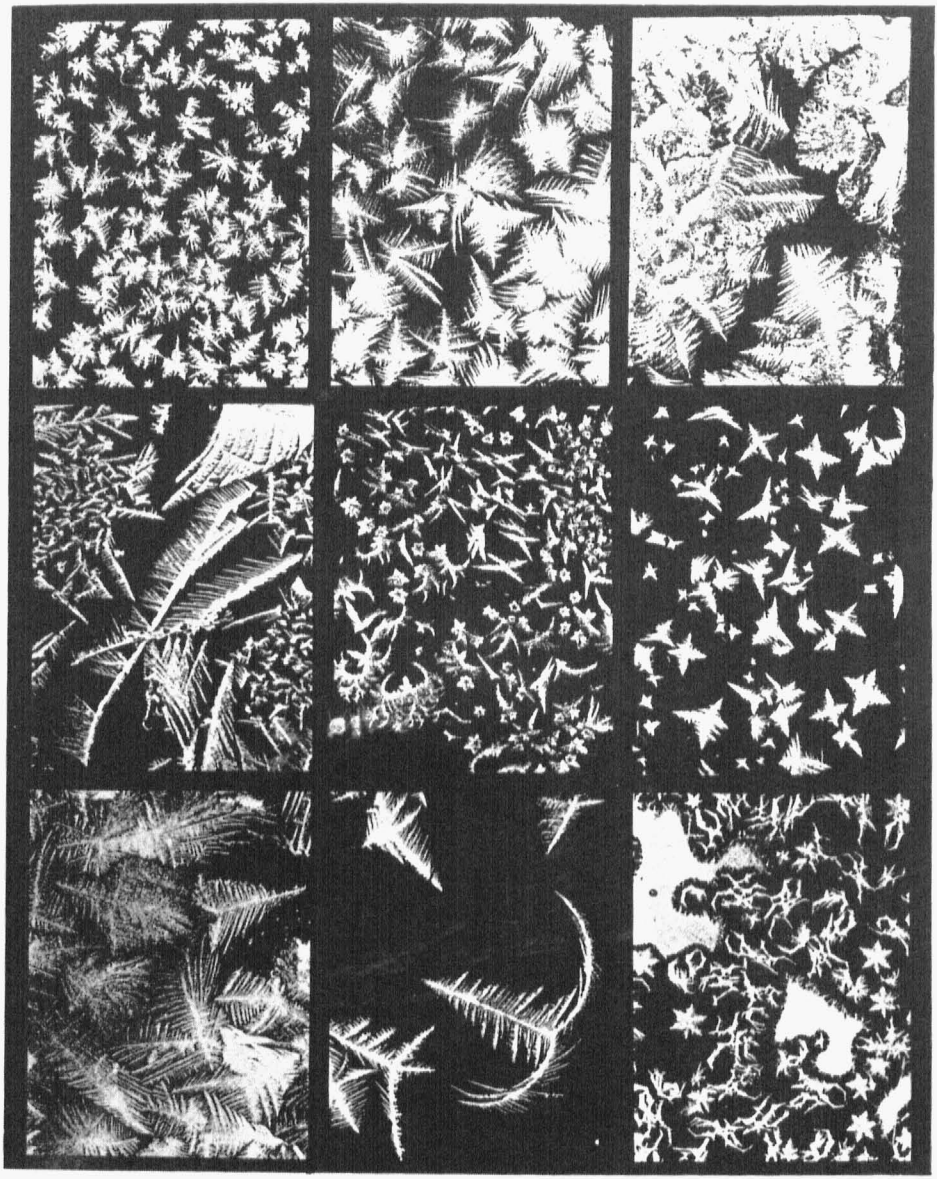
Under such conditions there is a narrow zone, where the cool air and the warm air meet, which is often spoken of as a *front*. In most cases the warm air will rise above the cooler air, thus causing the warm air to become cooler and resulting in the formation of heavy clouds. Rains caused by the presence of such fronts may become general ones, lasting for a day or two, and covering a good deal of country. In the winter time such conditions may result in snow, sleet, or freezing rain. When the warm air from the south is not well supplied with moisture, as is sometimes the case, only cloudy weather, with little or no rain, may result.

Thunder Storms

An interesting type of cloud formation, during the warmer parts of the year, is that which often results in thunder storms. These clouds are formed when the land surfaces become warm during the summer days, thus heating the air immediately above. Since warm air is lighter than cold air, masses of this warmed air will rise. As the mass of air is lifted it is cooled and the moisture in it will condense into clouds. The light, fleecy clouds (cumulus clouds), which often float across the summer skies, are the result of these rising air currents over the warmed land. Usually they are dark below where they are not illuminated by the sun and they may sometimes become so large and so dense that a real thunder storm develops, with pouring rain, lightning, and thunder. A good deal of the water used by crops during the summer months is from such thunder storms. Thunder storms may also occur in connection with general rains, but



These are ice crystals which make up snow flakes. When highly magnified, as these are, they are seen to be marvelously beautiful things. Almost all have a six point pattern with unbelievable variety of design. Think of the trillions and trillions that fall with each snow while no two ever seem to be alike. (Photo by permission, from *Snow Crystals* by Bentley and Humphreys. Copyright 1931. McGraw-Hill Book Co., Inc.)



Frost pictures on a windowpane. Do you remember when you were small you blew your warm breath against the windowpane to melt these away? And then you were sorry you did it. (Photo by permission, from *Snow Crystals* by Bentley and Humphreys. Copyright 1931. McGraw-Hill Book Co., Inc.)

these from the billowing clouds of the warm summer days are the most interesting.

Weather Predictions

The weather changes which result in clear skies or rain, warm or cool periods, are dependent on conditions of the upper air, miles above the earth's surface, as well as the air lower down. The study of weather changes and their causes, is known as the science of *meteorology*. The United States Weather Bureau has a large staff of trained meteorologists, taking observations at the many weather stations throughout the country. By careful studies of weather conditions over wide areas, both near the ground and at great elevations, by means of balloons, they are able to predict rain, snow, or other weather changes, two or three days in advance. Some predictions are now made with fairly good results, for thirty days ahead. The future will doubtless see great developments in the accuracy of these long-time predictions, with resulting benefits both to country people and to city people.

The Water Cycle

The water of the earth goes round and round. It goes from the ocean into the air as water vapor, then into clouds, then into rain or snow, much of which falls on the land. Some of that which reaches the land goes into the soil and some runs off.

Of the water which goes into the soil, much is taken up by plants and passed out into the air again as water vapor. However, some of the soil water evaporates into the air again.

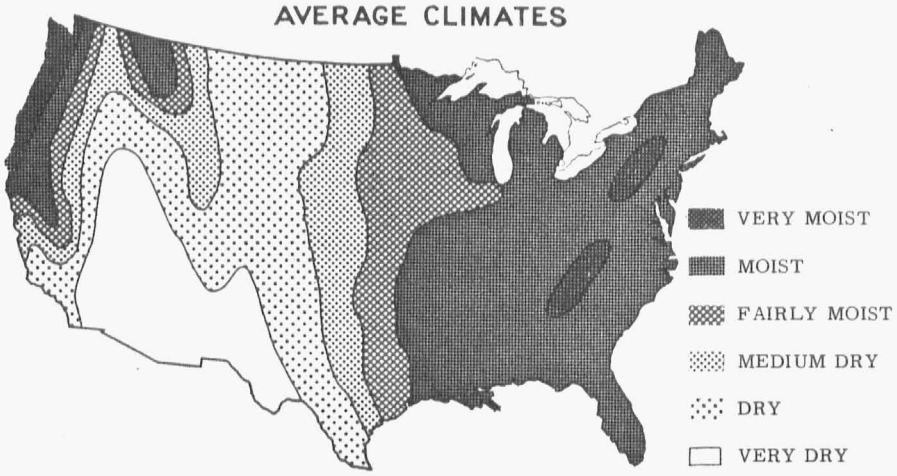
Believe it or not, these young folks are holding hands across the Mississippi River. This is where it leaves Lake Itasca, its source, in northern Minnesota. Compare its size here with that where it rolls by St. Louis or New Orleans.

This, along with that passed out by plants, adds to the moisture already in the air, to form clouds once more. Some of this may reach the land again as rain or snow.

Some of the water which enters the soil from rain or melted snow penetrates beyond the reach of plant roots and comes to the surface again as springs. It is this spring water, along with that which runs off the surface during heavy rains or melting snows, that forms the brooks, the creeks, the rivers, and lakes. In time, this again reaches the ocean and the round is completed. This round of water from the ocean to the air, to the clouds, to the land, to the streams, and again to the ocean is called the *water cycle.* The weather man calls it the *hydrologic cycle.*

The water cycle goes on constantly and all living things are dependent upon it. While there is no loss of water from the earth as a whole, during this cycle, some areas have very much rainfall and some very little. For instance, in the extreme northwestern part of the United States near Puget Sound, in the state of Washington, we have our heaviest rainfall. Here the warm moist air overlying the warm waters of the Japan Current in the Pacific Ocean, strikes the higher lands of the Coast where it rises, is cooled and pours down water in great quantities. The average annual rainfall at some points in this area reaches 120 inches. In other words, if it could all be collected on the ground at once the layer would be 10 feet deep.

At the other extreme regarding rainfall, are certain areas in the far southwest, such as the Imperial Valley of Southern California, where the air



This map shows the great climatic zones of the United States, as determined by moisture. They run from very wet to very dry and the agriculture, as well as the lives of people living in them, varies accordingly. (From Focus, American Geological Society.)

A lonesome place to live, on the dry plains of the West, where farms, or ranches, are large and houses few and far between. It's a matter of too little water.

is always dry, and where the average annual rainfall is only 5 inches. This is less than half a foot, as compared with the 10 feet at Puget Sound. It is interesting to know that the average annual rainfall for Missouri is about 40 inches or 3 1/3 feet.

There is another interesting thing about rainfall and that is the wide differences that may occur from year to year, or from month to month in many parts of the country. Missouri, as well as the other central states, may have too much or too little rain during many seasons. There may be droughts, very wet periods, or even floods, depending on the amount of rainfall during the different months of the year. One of the real problems of the farmers in Missouri and the other midwestern states, is to fit their farm operations to the water supply or to do what they can to control this supply to meet their needs.

Runoff Water

It has been mentioned, that when a rain falls, water enters the soil. If the rain is heavy all the pores or openings in the soil may become filled with water, after which some may run off. Sometimes, too, the rain falls more rapidly than the soil can absorb it and some of it runs away. The water that runs off the soil surface under either of these conditions, is called *runoff water*. It is this that often removes considerable amounts of surface soil through what is known as

soil erosion. Such runoff water is thus not only lost, so far as its use by crops is concerned, but it may also do much damage to the soil through erosion.

Water in the Soil

Without a supply of water in the soil, plants and animals could not exist. Mankind would perish from the earth. An abundant supply of soil water is therefore of tremendous importance to all of us. While in the main agricultural regions it usually comes directly from rainfall, in the drier regions it is supplied largely through artificial watering of the fields. This practice is known as irrigation.

The water for irrigation is commonly collected in reservoirs, or artificial lakes, behind large dams built across the rivers which flow from the rains and melting snows in mountainous regions. The level of the water in these reservoirs rises above that of the neighboring farm lands and it is brought onto the farms through large canals. From these canals it is run into smaller ones and from these it is carried over the farms by open

A field of sugar beets supplied with water through irrigation. The farmer can control the amount of water the crop receives so there will be no shortage.

ditches. The water is then spread on the fields by flooding, or through furrows between the rows of cultivated crops. In some places in the country, water is pumped into overhead pipes and spread by spraying.

The Influence of Forests

The thick layers of leaves and leaf mould under the trees of most forests acts like a sponge in catching much of the rain that falls. The amount entering the soil is therefore increased

while the runoff and erosion are much less than from cropped land.

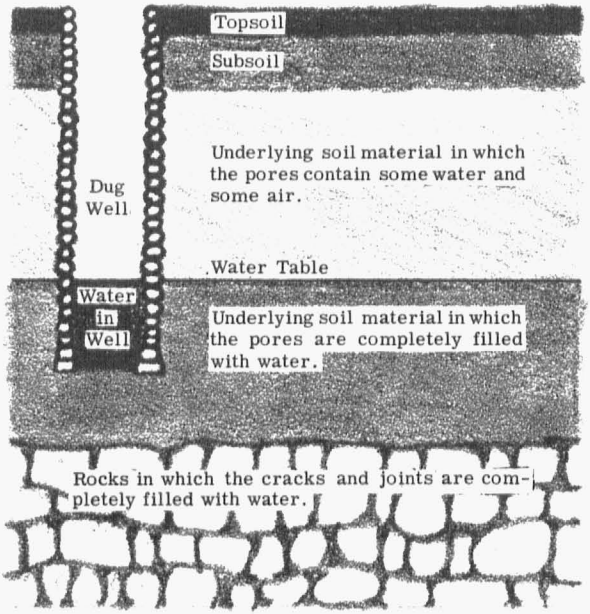
Large forest areas act somewhat like storage reservoirs, from which excess water, much of it from clear springs, runs away slowly. This regular flow of clear water provides supplies for domestic uses and for the production of game fish. The large forest areas have a great stabilizing effect on our flowing streams.

The Water Table

In the regions of abundant rainfall, particularly during the spring months, the deeper soil layers may become completely filled or saturated with water. Above the level where the soil pores are completely filled, the pores will contain some water, but also some air. The highest level at which the pores are entirely filled with water and where there is no air left in the soil, is called the *water table.*

During the summer months, in the central states, this water table usually sinks to 10 or 15 feet below the surface. When a well is dug in these areas it will fill to the level of the surrounding water table. The water table, therefore, determines the approximate depth of the water in the well. Sometimes, during long droughts, the water table sinks below the bottom of the well and the well goes dry.

Often in the spring, the rains are so heavy and prolonged that the soil completely fills with water. Thus the



This sketch illustrates the water table standing at a depth of 10 or 12 feet below the surface of the ground, as it often does in the Cornbelt during midsummer. Should there be a shortage of rainfall for a long period, the water table may sink so low that the well will go dry.

water table will reach the surface. Usually, however, in these regions, the water table will be found at depths of from 1 to 4 feet during most of the spring months. When digging a posthole at these times, the water table will often be encountered and water will run into the hole. In some places, however, the underlying subsoil is so tight that water does not pass through it readily and no regular changing, or fluctuating, water table exists.

Deep Ground Water

The term *deep ground water* refers to water which may exist deep in the underlying rocks. Where rocks are quite porous, or where they have many cracks and other openings, some of the excess water in the soil penetrates into them, and extends to great depths. This movement of water downward takes place very slowly, requiring many months or even years for its penetration. However, under some land areas it exists in great volume and provides water for the deep wells that are driven into the rocks. Such wells often supply water for farms, cities, industrial plants, and sometimes for irrigation.

The deep underground water is temporarily taken out of the water cycle, that is the round of water from the sea to the land and back again. Through the centuries, however, this water again reaches the sea, by flowing from the rocks directly into the ocean depths, so that actually the cycle is not broken.

CONTROLLING THE RAIN WHICH FALLS ON THE LAND

It has been shown that in the Corn-belt states, the amount of rain which falls varies greatly from season to season. Sometimes there is too much and sometimes too little for the best growth of crops. While there are no methods of controlling completely the water that falls, much can be done.

Controlling Runoff Water

During periods of heavy rainfall, particularly during those downpours which shower down immense quantities of water within a few minutes, considerable runoff from rolling lands will almost certainly take place. However, under the usual periods of rainfall, there is much the farmer can do to lessen the runoff that occurs.

Keeping the Soil Surface Open.—In order that a soil may absorb rainfall rapidly, the surface must be kept open and loose so that the water may go in readily. Where the surface is compact and hard, much water may run off. However, a soil surface which is loose and open, but not covered by a close growing crop may run together and become largely sealed over during a heavy rain. Such sealing of the surface is due to the beating of the raindrops and it usually occurs during the early period of a

pouring rain so that much of the water which falls later will run off.

There are three things the farmer can do to increase the entrance of

A thick-growing sod crop of clover, alfalfa or grass, causes the soil to take up much of the rain that falls. Here is a father explaining to his boys the value of this field of Ladino clover.

water into the soil. First, he can keep his soil as mellow and open as possible, through good systems of cropping, proper tillage methods, and the use of farm manures. Second, he can increase the amount of sod crops in his cropping system, since these crops keep the soil covered and speed the rate of water penetration. This is one of the advantages of the system of "pasture farming" which is being recommended by the College of Agriculture and which large numbers of Missouri farmers are adopting. Third, he may at certain times, keep the soil covered with some kind of organic matter, such as crop stubble, manure, or even clipped weeds. This layer of organic matter takes the beating of raindrops and keeps the soil surface more open.

It is true that during heavy and long continued rains, the soil may become completely staturated with water so that much may run off. However, with the ordinary rains, proper control measures may prevent much runoff from taking place.

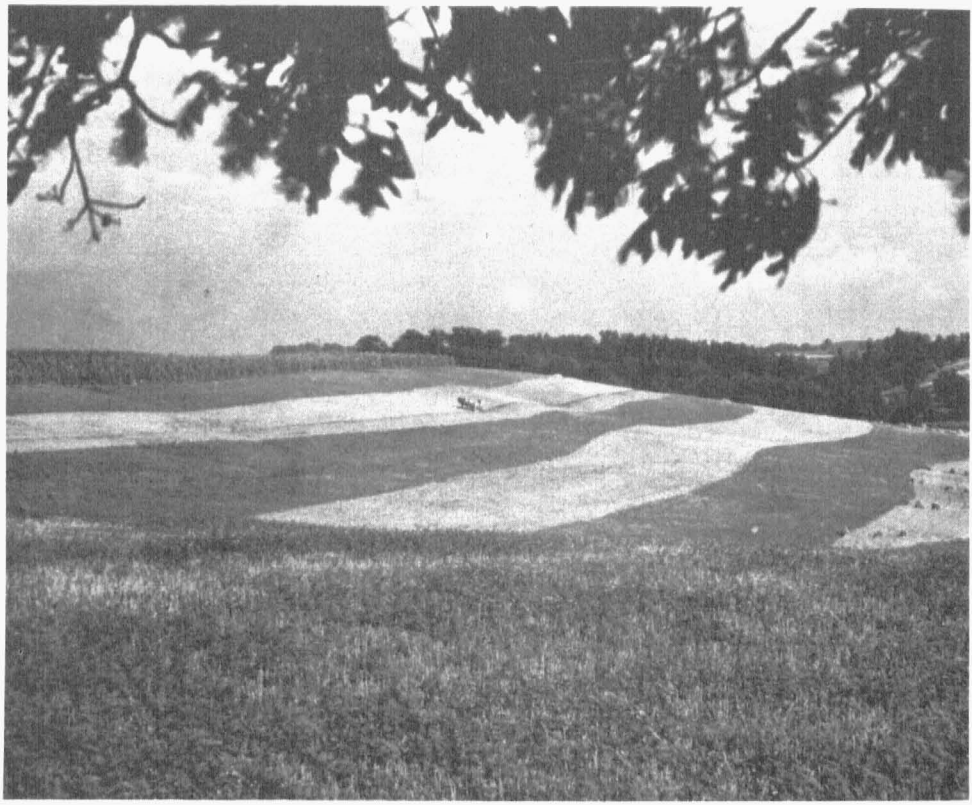
Contour Farming.—A plan of cropping which has come into use in Missouri rather recently is known as *contour planting,* or *contour farming.* It provides for running the rows of corn or other crops across the slopes of a field, rather than running them parallel to a fence line or field border. Formerly, farmers took pride in the straight rows they could plant, but on sloping land this meant that the rows ran up and down field slopes. In such cases the water of heavy rains

This is a field of corn planted on the contour. Contour farming, such as this, cuts down the amount of runoff water, on rolling lands, and also decreases soil erosion. As a rule, it increases the yields of grain crops around 10 per cent and it is not a difficult practice to follow. (Courtesy Soil Conservation Service)

would run rapidly down the small furrows left by the cultivating and planting equipment, so that both runoff and soil erosion were increased.

When crops are planted and cultivated across the slopes, or nearly so, the little furrows and ridges tend to act as small dams which hold back much of the water and allow it to enter the soil. This lessens not only runoff, but soil erosion as well. Contour cropping is now followed on many Missouri farms and its use is likely to increase greatly in the future.

Strip Cropping.—Another plan of planting crops across the slope, to lessen runoff and erosion losses, is what is known as *strip cropping.* Under this system alternate strips of such crops as corn, wheat, and clover are planted across the general slope of the field. Such strips are usually from 100 to 300 feet in width, with one crop planted above another. The runoff water and the eroded soil from the bare ground of a corn strip is largely caught in the thicker growing wheat or clover in the strip or strips



A beautiful view of strip cropping for reducing the amounts of runoff and erosion from sloping land. This practice is very common in some states but it is not much used in Missouri. (Courtesy Soil Conservation Service)

below, and most of it is thus held on the field. While there may be some loss of both water and soil from the wheat, there is very little from clover or grass strips.

Strip cropping is used very extensively in some of the eastern states, such as Pennsylvania. It is not so common in the states of the Middle West although the plan is followed to a considerable extent in Wisconsin and on smaller areas in some other states. Thus far, the practice has not become common in Missouri.

Terracing.—The plan of throwing up broad ridges, or *terraces,* across the slopes on rolling farm lands is followed to some extent in all the midwestern states. These broad ridges look like graded road beds with wide, shallow channels above them. The water and soil coming down the slopes is caught in these channels, where the soil is retained, while the excess water is led slowly away to grass covered outlets. The land between the terraces is usually planted on the contour, and this holds back a good deal of the water and soil. Moreover, some of the water coming into the terrace channel soaks in so that the effect of contour farming and terracing together, is to save much of the runoff water and to cut down soil erosion. While terraces are built largely for controlling soil erosion losses, the use of both contouring and terracing helps greatly in controlling the runoff water.

Many farm boys are learning how to lay out the lines for making terraces and for establishing contour farming systems. The teachers of vocational agriculture in the high schools often have their pupils learn these methods. Even some of the 4-H boys have tried it. By the time these young people are middle-age farmers most of the rolling land in Missouri may be handled under such systems.

Conserving the Water Which Enters the Soil

Since the amount of water in the soil during the growing season is often too small for the best growth of crops, something should be done to conserve it. Where the dry period, or drought, is prolonged, all the soil water within reach of crop roots may be used up and crops will suffer greatly. There are, of course, seasons when rainfall during the growing season is abundant and these are usually the big crop years. But during seasons of drought, widespread crop failures may result. It is always wise, therefore, for farmers to find means of controlling the water which enters the soil during the late spring and summer months.

The Use of Soil Mulches.—A soil mulch is a loose layer of soil on the surface of tilled land, such as that in a cornfield. It is formed by tillage implements and, unless rain falls soon, it becomes rather dry. In this condition it acts somewhat as a blanket on the surface to cut down the evaporation of water from the moist soil beneath.

The soil mulch was formerly widely recommended for conserving soil water in cultivated lands during the

summer months. In more recent years, such recommendations are rarely made. The principal trouble with a soil mulch is that every shower causes this loose, dry layer to run together and seal over, thus destroying its blanket-like effect. Moreover, when the mulch is formed again, most of the water must evaporate from this layer before it becomes active as a mulch. In the case of small showers this loss may be more than the mulch will save later.

Another difficulty with a soil mulch is that the farmer may allow his cultivator shovels to run too deeply, thus cutting many roots of corn or other cultivated crop. Under such conditions he may be doing more harm than good.

It is now known that the principal value of making a soil mulch is in controlling young weeds as they start. If this is done with a harrow or other implement that stirs only a shallow layer of the soil, few roots will be cut and a small amount of moisture may later be saved. However, this

The best farmers who are handling rolling land are putting in "water management" systems on their farms. Here is a broad, shallow water-way which the farmer has built and seeded to grass. Its purpose is to carry, without erosion, the water from the terraces that can be seen emptying into it. (Courtesy Soil Conservation Service)

saving will never be very great, so that the soil mulch has lost its former popularity.

The Stubble or Trash Mulch.—A mulch that is really effective in conserving the supply of soil water is the *stubble* or *trash mulch.* This is a layer of the dead parts of plants of any kind, such as straw, the stubble of small grains, or corn stalks, chopped up with a sharp disk harrow or other cutter. Dead weeds or farm manure also represent such a mulch. Such mulches have long been used, to some extent, in gardens or on vegetable farms. Modern implements have made them practical on large fields.

The widest use of the trash mulch is on the wheat lands of the dry plains where it is giving excellent results. It not only decreases the loss of moisture from these dry-land soils, but it increases the amount which goes in. Farm implements have been developed which will work the soil beneath and still leave most of this layer of dry organic matter on the surface. Wheat, oats and other crops can than be sown beneath the mulch and the young plants will come up through it. The extra moisture beneath the mulch greatly improves the growth of crops.

This is a "trash mulch" made up of grain stubble and dry lespedeza. It causes more moisture to enter the soil and decreases evaporation from the soil surface. A special tillage implement is working the soil beneath, so that wheat may be sown and still leave much of the mulch on the surface.

This is one of the most interesting developments in farming the western plains.

Controlling Excess Water

Very often, in the spring of the year, there is too much rainfall. When this extends into the planting and growing season it has a bad effect. It may greatly delay the time of preparing land and of planting crops. Moreover, heavy rains may come after crops are planted and as a result, crop growth, particularly on level lands, will practically stop. Those are the times when the young corn turns yellow and the farmer becomes discouraged. Sometimes, too, such a wet spring is followed by a drought and then the farmer is in real trouble.

The control of excess water in the soil is brought about by artificial drainage of the land. This is done in two ways. First, there is the use of small open ditches in the fields which lead to a larger drainage ditch or a stream. This is called *surface drainage*. Second, there is the use of *tile drains* beneath the soil. In some cases both tile drains and open ditches are necessary.

Open Ditches.—The greatest use of open ditches in the midwestern states is in the large areas which were originally swamp lands. The largest of these is in the Southeastern Missouri region where there are six counties which represent the Delta lands running up from the Gulf of Mexico. This

Deep open ditches, or canals, like this one, are used for carrying away large amounts of water in draining extensive areas of swamp land.

great expanse of bottomland has been drained by the construction of immense open ditches, along with hundreds of smaller ones opening into them.

There are many areas of wide extent along the Mississippi and Missouri Rivers which have been drained. Other large areas of land which were originally swamp are found in the level lands of Illinois and some other states. While some such lands are still wet, particularly in some large river bottoms, most of the originally wet land in the central states has been drained.

Tile Drains.—Drain tile are moulded from a wet mixture of soil and subsoil, containing a good deal of clay, and burned to a brick-red color in kilns. They are from 4 to 10 inches in the diameters of the openings and they are laid end to end in trenches, usually 2½ to 3½ feet deep. The 4 and 5 inch tile are laid under the fields usually at distances from 100 to 300 feet and they empty into larger ones which carry the water to an open ditch or small stream where it flows away. The various strings of tile are laid with a slight slope or fall, so that the water drains away rapidly.

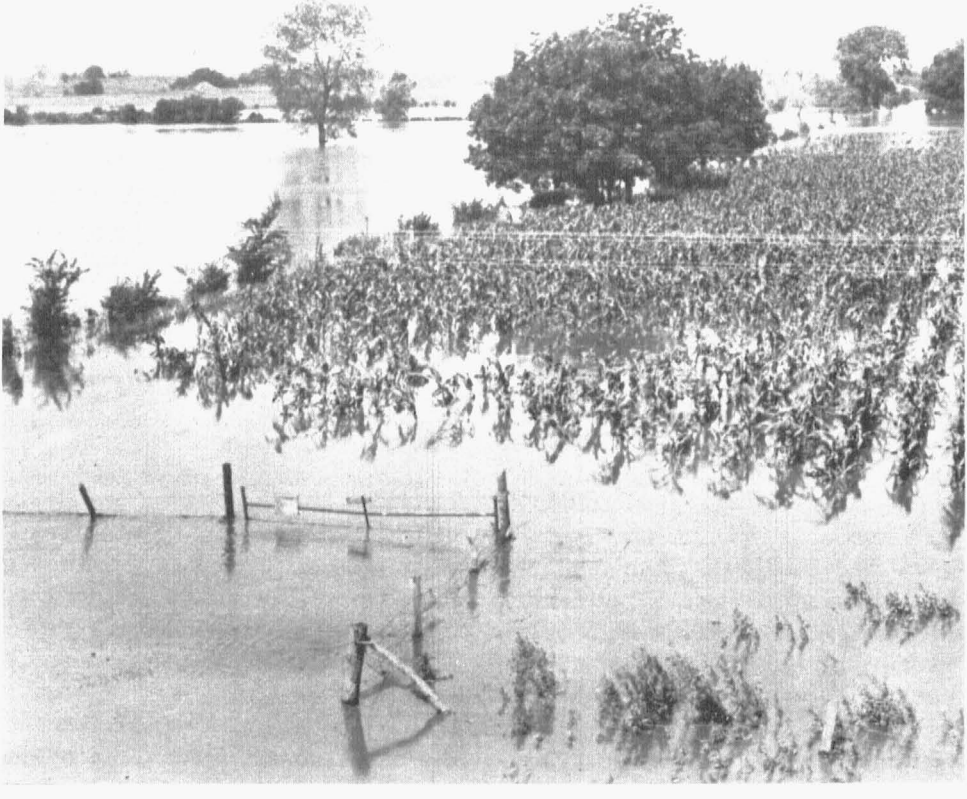
Almost all of the level lands in Illinois, Indiana, Ohio, and parts of Iowa and southern Michigan have been tile drained. Some such land in Illinois, for instance, was formerly swampy and worthless for farming, but through the use of tile, along with some large open drains, it has been transformed from waste land to some of the most productive in the world.

This man is laying drain tile beneath level Cornbelt land. Enormous numbers of such tile have been laid beneath the level lands in this great area. However, the subsoils beneath most level lands in Missouri are so tight that tile do not work as well as in other midwestern states.

Its value has increased from practically nothing, in the wet condition, to $200, $300, or even $400 per acre in some cases. Tile drains are not commonly used in the level lands of Missouri. This is due in part to a rather long growing season and in part to the rather tight clay subsoils beneath the level lands, which prevent the ready movement of water to the tile.

The Control of Floods.—One of the results of too much water on the land is the occurrence of floods. In such cases, there is so much runoff that the stream bottoms are flooded and much damage may result. In many instances crops on these bottomlands are completely ruined. Often, too, the floods do great damage to highways, roads, and buildings. Sometimes there is considerable loss of life. The floods of 1951, in Eastern Kansas and Western Missouri, were the worst in 100 years. However, some damaging floods occur almost every year, in some parts of the country. They cause great difficulties in handling bottomland farms. Estimates place the losses from floods for the United States at over a half billion dollars annually.

While a good deal has been accomplished in controlling the smaller floods, little has been done that is effective in controlling the larger ones. The most widespread control measure for the ordinary floods, is the building of levees along the main streams to hold the water off the overflow lands.



A flood like this may do great damage to crops on bottom lands. Better methods of controlling floods must be worked out.

Of course, during the larger floods the levees often break, and much damage is done, not only to bottomland crops, but to the levees which may be costly to repair.

The army engineers have planned a system of flood control reservoirs to hold back the water along some of the main rivers of the country. In some cases, where dams have been put in, these have been partially effective, but they have not solved the flood problem. The reservoirs above the dams cover large areas of the best land, sometimes taking more good land out of cultivation than is protected below them. Moreover, it will require immense expenditures to build all the reservoirs needed and even if these were all constructed it is very doubtful if they would control the large floods. The large floods are usually caused by very heavy rains following rains which have already soaked the soil with water. Under such conditions no control measures can be expected to prevent a flood.

Soil Management Practices As Means of Flood Control

A good deal can be done by upland farmers in cutting down the water losses from their farms if they use the best methods of controlling runoff. As previously shown, something can be gained by growing considerable acreages of sod crops which hold back runoff water and allow more water to soak into the soil. Contour farming and terracing lessens runoff and sometimes strip cropping helps hold the rainfall on the land. The building of deep farm ponds will store some water. Finally, if farmers keep their soils mellow and open, more rain water will be absorbed. These various measures, where fully employed, will hold much of the water on the farms and lessen the danger from the ordinary floods. While such measures cannot be expected to control floods completely, they will prevent some of the smaller ones and lower the peaks of the larger ones. The principal difficulty is in getting all farmers to follow these practices.

WATER FOR IRRIGATION, FOR CITIES, AND FOR INDUSTRIAL PLANTS

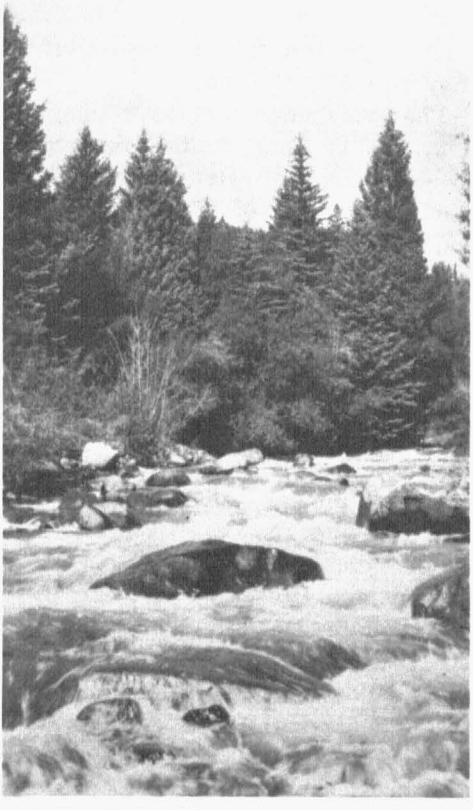
Much money has been expended in constructing large reservoirs or artificial lakes for storing water, or in drilling deep wells and pumping it for irrigation purposes, for the use of cities and for industrial plants. These are the principal ways in which the people of the country are using water.

Reservoirs for Irrigation Water

Most irrigation systems are located in the western states, where they are supplied with water from the nearby mountain ranges. The high elevations of the mountains, with the resulting

low temperatures, cause the moisture in the rising currents of air to condense and to be precipitated as rain or snow. Everyone who has spent time in the Rocky Mountains is familiar with the mountain showers of the summer afternoons and with the heavy snows during most winters. It is from these rains, and from the melting snows during the summer seasons, that the many reservoirs of the West are filled with water for use during the growing season.

The Grand Coulee Dam, on the Columbia River in Oregon, forms the largest reservoir in the country. The water from this one reservoir is sufficient to irrigate almost a million acres of farm land. At the same time it provides water power for generating a million kilowatts of electric energy. The Hoover Dam across the Colorado River in Arizona is another huge dam which forms the Lake Meade reservoir. The water from this reservoir is sufficient to irrigate a half million acres of land and also to generate a very large amount of electric current. There are other large reservoirs in the western states along with scores of smaller ones.



A fine Rocky Mountain stream. It has ice-cold, crystal-clear water from the melting mountain snows. Some such streams have an abundance of mountain trout.

A total of 20,000,000 acres of farm land is now under irrigation in the western states, and most of it is supplied with water from these reservoirs. It is estimated that an equal area of dry land in this region is suitable for irrigation if enough water could be supplied at a cost which would make it profitable. However, if it were economically possible to irrigate all this additional land, the total irrigated acres would represent only about 4 per cent of the total number of farms in the United States. On the other hand, lands under irrigation are usually very fertile, and where the water can be supplied as needed, they produce very large yields of general farm crops, fruits, and vegetables. This means that in spite of the cost of irrigation such lands supply great quantities of agricultural products to the markets of the country.

Irrigation Water from Deep Wells

In some of the irrigated areas of the West the water is pumped from wells which reach the deep ground water found in underlying masses of soil material or the underlying rocks. Such wells usually produce a very satisfactory supply, at least for a number of years. It has been found, however, that in many of these areas this deep ground water is pumped out faster than Nature can replace it, so that the wells must be driven deeper and deeper. In cases where the wells are near the ocean, salt water will often come in as the fresh water is removed. The wells then become useless. The difficulties in securing irrigation water from deep wells present problems that have not yet been solved. While such deep wells are now supplying only about 15 per cent of the water used for irrigation, a continuous supply from such sources is very important to those farmers who are dependent upon it.

Water Supplies for Cities

The modern city requires great quantities of water. In the larger cities in the eastern half of the United States the supplies are from lakes, from large rivers, from reservoirs, or from deep wells. In the western states reservoirs are the principal sources of supply although some comes from deep wells. Many cities scattered throughout the country, which, a few years ago had plenty of water, are now running short and some are bringing it in over long distances.

The amount of water used varies a good deal from city to city, but estimates indicate that for those of over 100,000 population, the average daily home use per person is between 120 and 140 gallons. Think how much water that is for one person to use every day. It certainly should provide for a lot of baths per week. But this amount is only for household purposes. It doesn't include the many other uses of water in cities, including that of the many industrial plants. If all these city uses of water are combined with those of country people, and those for irrigation purposes, the total amount of water required for each individual in the United States is close to 1,000 gallons daily. That's an enormous amount.

Some City Water Problems

Consider just what it would mean if the water supply of a city, such as New York, Philadelphia, or Chicago, with millions of people, were suddenly cut off. Unless water for drinking purposes could be brought in quickly, people might be dying from thirst. They might get along without baths or clean clothes for a good while, but not without water to drink.

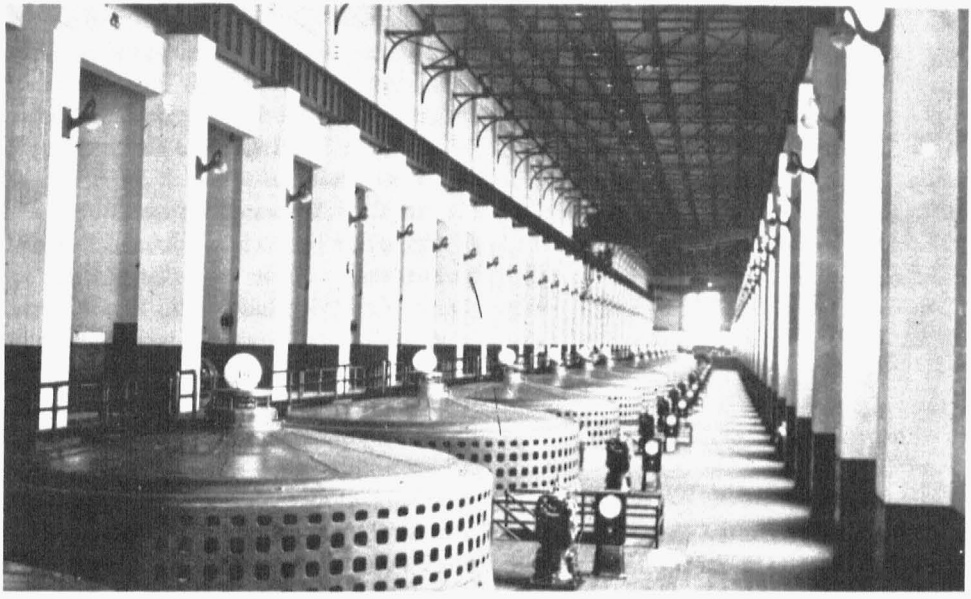
A real problem in providing water for cities has to do with its quality. It must be pure, reasonably free of dissolved substances such as soluble salts, and it must be free of dangerous disease germs. Where over a half million people drink from the same water supply every day, as in our large cities, it would be a terrible calamity if large numbers of disease germs found their way into it.

Some of the larger cities have been compelled to go long distances and utilize various means of securing sufficient water for their needs. Los

Angeles is an interesting example. There are now about 3,500,000 people in the Los Angeles area and most of the water for their use is carried by aqueducts and tunnels from the Colorado River, in Arizona and from other rivers at distances of 150 to 250 miles. Think what it would mean if an earthquake would shatter these water lines!

Industrial Uses of Water

Mention has been made of the fact that water used in cities is partly for industrial purposes. In some of these manufacturing plants the use of water is extremely large. Such plants may take many times the amount of city water used in other ways. It is said that the average daily use of water



Interior of a large hydroelectric plant for generating electric power, through the action of falling water. It supplies current to farms, cities, and industrial plants over a wide area.

by the nation's steel mills is four and a half times that of the city of New York with its eight million people. Statistics also indicate that an individual coke plant may use as much as fifty million gallons daily. In some methods of manufacturing paper, 100,000 gallons of water are used for each ton of paper produced. It is, therefore, evident that large-scale production in American industry has meant a great increase in the use of water.

The problem of providing sufficient water to take care of industrial plants whether inside or outside of cities is a most difficult one. Cities on the Great Lakes, such as Chicago, Milwaukee, Cleveland, and Buffalo have little difficulty, but those which must depend upon artificially constructed reservoirs, deep wells, or streams of moderate size have great problems.

Water Supplies for Generating Electric Power and Light

It is said that the early Indians in this country never seemed to realize that there was power in falling water. It's difficult to believe, however, that some of the Indian boys along the East Coast, where there were plenty of rushing streams, didn't devise some kind of a small water wheel, just to see it run. Anyway, it's a long step from that day to this, when immense amounts of electric power are developed from water as it flows from the land areas back to the sea.

The water power plants in the United States now generate power equal to that of 24,000,000 horses, or, as is commonly said, 24,000,000 horse power. Over 40 per cent of this is produced in plants along the Pacific Coast, about 25 per cent in the Rocky Mountain region, and 10 per cent in the Middle Atlantic states, where there are large industrial developments. The remaining 25 per cent is developed in various parts of the country.

Unlike coal or other fuels that are used for the generation of power, the supply of water, where properly handled, may be inexhaustible. It is a part of the ever continuing water cycle. It has been brought to the higher altitudes by rain or snow and it is on its way down to the sea again. When properly handled this falling water will produce great quantities of electric power.

CONSERVING WATER FOR CITIES, IRRIGATION, AND INDUSTRY

The methods of conserving water for crops have been discussed. The means of conserving it for use by cities including industrial plants, and for irrigation purposes, are just as important. Here are some of them.

Prevention of Stream Pollution Conserves Water

New York City brings most of its water from the Catskill Mountains, over 100 miles away. At the same time the great Hudson River rolls by to the sea. The water of the river has been so badly polluted by sewage from other cities and towns, and so poisoned by industrial wastes, before it reaches New York City, that it cannot be used. This is one of the worst cases of stream pollution ruining the use of flowing water, but there are many others. It would certainly be a great saving of water for modern uses if this pollution could be controlled. There is little doubt that, in the future, much will be done to bring about such control measures, and if this is successful, such waters may again be made fit for man's use and for the fish that formerly flourished in these streams.

Conservation of Deep Ground Water

Mention has been made of the use of deep ground water for irrigation in some of the western states as well as for some cities. It should be understood that the amounts of this water vary from place to place, depending on the openings and other conditions in the underlying rock or soil material. These amounts also vary with the rainfall from decade to decade. However, they remain nearly the same at any one place, unless man taps the supply and pumps out the water faster than Nature can replace it. When this happens, serious trouble may result.

There are many examples of too great a use of ground water by cities widely scattered throughout the country, from east to west. Similar shortages have come about in those irrigation districts of the West where ground water is the main source of

This church, constructed of dried mud blocks and mud plaster, (known as adobe) was built by the early Spanish settlers in the dry climate of New Mexico over 175 years ago. In Missouri the rains would have melted it down within a year or two.

supply. In many cases these overdrafts on the deep water shortage are threatening the future development and even the present existence of some cities and many industrial plants.

While it should not be understood that a general exhaustion of deep ground water throughout the United States is likely to take place, in those areas where the use is outrunning the supply, some means must be found for conserving it. Fortunately, in some places near the mountains on the west coast, the ground water supplies may largely be replenished by the use of proper methods. In other cases, such methods cannot be used

and the slower action of Nature must be depended upon. This means that in many places the amounts pumped from the underground must be cut down and other sources of water used to meet a part of the demand, at least while Nature replenishes these underground supplies.

Wasteful Uses of Water Should Be Stopped

In most places water has seemed so abundant that people have developed the habit of using it in wasteful amounts. However, as the population of the nation has increased, particularly in the cities, we are coming to realize that water can no longer be wasted. It must be conserved by cutting down on its excessive use.

It is, of course, true that the rainfall of the United States is not greatly different from what it was when Columbus landed on the east coast, 460 years ago. The water cycle goes round and round, as it always has done, and as it will probably do for centuries to come. Actually, much of the water we are using today may

A view on the Lake of the Ozarks showing the rocky hills and bluffs surrounding it. The clean shorelines, free of logs and brush, help to make it a fine recreation lake.

have fallen on our lands before. However, as we have seen, the amount of rainfall varies greatly in different regions, from a few inches to many feet. Moreover, man's demand on the supplies have not only increased enormously, but the needs vary greatly from place to place, depending on the density of the population. It is very evident, therefore, that in all areas where there are many people and where large amounts of water are needed, water can no longer be wasted.

Water as a National Resource

It can be said, in brief summary, regarding water and its conservation, that the total amounts of water received by the land surfaces of the country are probably the same now as they have been for centuries. Moreover, the amount of rainfall varies greatly from region to region as it has done since white men appeared on our east shore. In other words, the conditions regarding rainfall have not changed. However, as the country has become more completely populated, particularly with large numbers of people in certain areas, the demands at these places have become greater than the local supplies of surface water will provide. In such cases, it has become necessary to bring in water for long distances or to sink wells to tap the supply of deep underground water. In some cases both means are used.

It is quite evident that in many areas, water conservation has become of great importance and plans for the best uses of water should be worked out. Thus far, the country has no well organized plan. Progress has been made in developing one, but the plan is far from complete. We should all recognize that water is a natural resource, and that in many areas the supply is insufficient for man's needs. We should, therefore, determine all possible sources of water for the future, both above and below the ground. We should plan for its conservation and wise use. Only through such means will the future of the people be secure.